Research on mineral processing of low quality kalium-natrium feldspar

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Abstract: In light of characteristic of low quality feldspar ores in Wanzai County, Jiangxi Province, steel ball was taken as grinding medium, and selective grinding could make impurity separate from feldspar effectively. Through the flow of flotation-desliming-high gradient magnetic separation, the feldspar Concentration 1 was obtained with the yield of 70.19 %, containing Fe_2O_3 0.17 % and TiO_2 0.07 %. The feldspar Concentrate 1 could meet the quality requirement of high-grade construction ceramic. And the slime that was deslimed in the flow was also separated and recovered; the feldspar Concentration 2 was obtained with the yield of 13.18 %, containing Fe_2O_3 0.31 % and TiO_2 0.17 %. The feldspar Concentrate 2 can be used for raw material of low-end ceramic. And gangue, with the yield of 16.63 %, was thrown away in this flow, the separating efficiency was high. Employing this flow could also bring high economy benefit and low influence of pollution to environment.

Key words: feldspar; Fe_2O_3; grinding; magnetic separation

1 Introduction

Kalium-natrium feldspar is a kind of silicate mineral, which is enriched in kalium and natrium. It is one of the four ceramic essential components (i.e. kaolin, quartz and binding clay), because of the low melting temperature, the molten interval time stability and high chemical stability. This property of feldspar reduces the melting temperature of ceramic. After glazing, feldspar that is free of impurities and good quality looks pleasant, but high quality feldspars in the world are rare. In our country, although the resource of feldspar is abundant, high quality feldspars are also rare. Many of them contain impurities, such as iron and titanium. If feldspar contains iron, the whiteness after glazing is lower, and there are black spots in the surface. The combined action between iron and titanium will prominently influence the whiteness of feldspar after glazing. Generally speaking, feldspar containing $Fe_2O_3 < 0.2$ % and $TiO_2 < 0.1$ % can meet with the quality requirement of ceramic products in the ceramic industry. In this research, the main aim is to find the optimum mineral processing scheme to remove iron and titanium impurities from the kalium-natrium feldspar.

2 The property of ore

2.1 Chemical analyses and mineral composition

Feldspar test sample came from Wanzai County Jiangxi Province. The chemical analysis of the ore had shown that the ore was composed of Na_2O 6.52 %, K_2O 6.03 %, Al_2O_3 19.38 %, SiO_2 65.90 %, Fe_2O_3 0.46 %, TiO_2 0.11 %, MgO 0.14 %, CaO 0.38 %, P_2O_5 0.23 %, MnO 0.008 %, Li_2O 0.000 4 %, S 0.04 %, H_2O 0.10 %, and L.O.I 1.05 %. From the chemical analysis, it was concluded that feldspar-containing $Na_2O + K_2O > 12$ could meet the requirement of feldspar concentrate, but the concentration of Fe_2O_3 was too high, and the concentration of TiO_2 also couldn't meet the requirement of ceramic industry. So this kind of feldspar belonged to low quality feldspar. Only high quality feldspar can be obtained through reducing the concentration of iron and titanium impurities.

By microscope, X-ray diffraction and electron probe microstructure analyzer, we found that the main minerals were natrium feldspar, kalium feldspar, and plagioclase; the subordinate minerals were quartz, mica and calcite; the rare minerals are apatite, rutile, pyrite, hematite and rare earth minerals, etc. Natrium feldspar and kalium feldspar were found as large crystals in the texture of the ore, without iron or titanium containing in their crystals. Most of iron is rich in pyrite and mica, and the content of iron in mica is higher than pyrite. But they are distributing along feldspar crystals. The titanium in the ore is in the form of rutile, and its crystal was very fine, generally less than 2 μm. The distribution of rutile was also along feldspar crystals. So

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the purifying of low quality kalium-natrium feldspar mainly aimed to remove mica, pyrite and rutile .

2.2 Distribution of iron and titanium

In order to avoid being polluted by iron again, porcelain ball was chosen as grinding medium. Through grinding and screening, the distribution of iron and titanium in various size classes was determined. Iron and titanium is mainly distributed in −0.045 mm class and the contents of iron and titanium were 55.15 % and 53.34 % respectively. The second higher distribution of iron and titanium was in +0.045 ~ −0.074 mm class, the contents of iron and titanium were 15.30 % and 18.43 % respectively. So iron and titanium were mostly distributed in fine class. Trough further study on −0.045 mm class by sedimentation classification, it was found that the distribution of iron and titanium are mostly distributed in −20 μm class.

3 Experimental

3.1 Grinding

Steel ball and porcelain ball were taken as grinding medium and grinding and concentration was 50 % of this experiment.

3.2 Mineral concentration

In light of characteristic of low quality feldspar ores in Wanzai County, Jiangxi Province, different experiments such as desliming, magnetic separation and flotation were completed to make iron and titanium impurity separate from feldspar. −20 μm class mineral muds were deslimed by desliming tundish.

Because iron impurities contained in feldspar ores in Wanzai County, Jiangxi Province is weakly magnetic; magnetic separation effect of commonly magnetic separation equipment is weak. So slon-100 cycle high gradient magnetic separator was used as magnetic separation equipment.

In light of feldspar ores containing pyrite, which couldn't be effectively removed by magnetic separation, so the test adopts flotation to remove it. Butyl xanthate and 2# oil were selected as collector and frothing agent respectively. Vitriol was used as adjusting-pH agent, and right pH was set 6.0. Lab-used single flotation cell of XFD-63 was selected as the floatation machine.

4 Results and discussion

4.1 Grinding

4.1.1 Comparison of grinding medium

The results of high gradient magnetic separation with different grinding medium were given in Table 1. As seen from the Table 1, if the ore was grinded with steel ball, the iron content in raw material would increase. But the iron content of magnetic products with steel ball was a little higher than porcelain ball under the same magnetic condition; the increment was only 6.45 %. However, the grinding efficiency of steel ball was much higher than that of porcelain ball. The content of −0.074 mm class with steel ball was much higher than that with porcelain ball and the increment is 23.45 %. So considering economic benefit, the suitable grinding medium was steel ball. And considering the characteristic of low quality feldspar ores—the distribution of iron and titanium is along feldspar crystals and the crystal of feldspar ores in the texture is large, selectivity grinding is suitable to make impurity separate from feldspar efficiently. The contacting of steel ball and ore was dot contacting, the impurities distributed along crystal were easy to grind and separate form feldspar crystal, so the large feldspar crystals were protective. Comparing with steel ball, grinding was uniformity because the contacting of steel stick and ore was line contacting, so the large feldspar crystals were easy to grind. Though the analysis, steel ball was a kind of suitable grinding medium for selectivity grinding.

Table 1 The results of high gradient magnetic separation with different grinding mediums

Background magnetic intensity/T	Products	Porcelain ball (−0.074 mm 49.86 %)			Steel ball (−0.074 mm 61.50 %)		
		Yield/%	Fe_2O_3/%	Iron remove/%	Yield/%	Fe_2O_3/%	Iron remove /%
1.0	Non-magnetic	90.42	0.31	—	89.21	0.33	—
	Magnetic	9.38	1.92	39.15	10.79	2.00	42.31
	Total	100.00	0.46	—	100.00	0.51	—

4.1.2 Grinding size

The result of high gradient magnetic separation with different grinding size was given in Fig. 1. As showed in Fig. 1, the effect of magnetic separation firstly increased with the increasing of the grinding size, but then decreased. Clearly visible magnetic effect maximum was observed at the size that the rate of. In order to obtain the better magnetic effect, the grinding size should be controlled at size that the rate of −0.074 mm passage was 60 % .

4.2 Desliming

After desliming, the feldspar containing Fe_2O_3

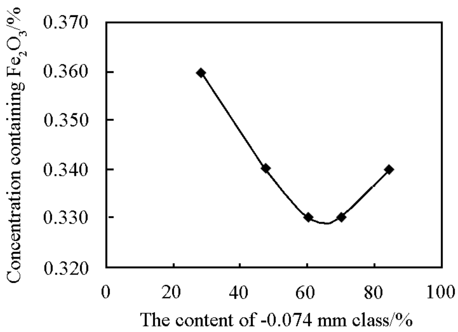


Fig. 1 The effect of high gradient magnetic separation with different grinding size

0.36 % and TiO_2 0.09 % was obtained. Comparing with raw material containing Fe_2O_3 0.47 % and TiO_2 0.11 %, the removal rates of iron and titanium remove are 33.61 % and 29.09 % respectively. So desliming can effectively decrease the content of iron and titanium in raw materials.

4.3 High gradient magnetic separation[1]

High gradient magnetic separation used steel meshwork as magnetic medium. The effect of high gradient magnetic separation with background different magnetic intensity is given in Fig. 2. As showed in Fig. 2, the curve was smooth at the background magnetic intensity of 1.0 T; the removal effect of iron was

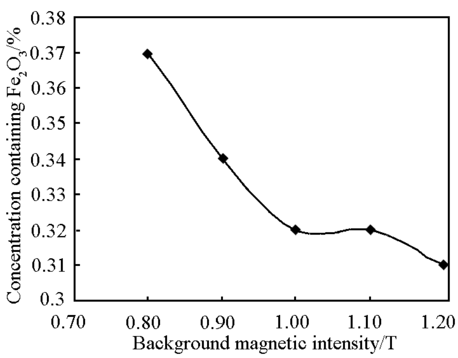


Fig. 2 The effect of high gradient magnetic separation with different background magnetic intensity

increasing a little after 1.0 T. Considering the economic benefit, the suitable is 1.0 T. The effect of high gradient magnetic separation with different velocity of pulp is given in Fig. 3. As showed in Fig. 3, the slower the velocity of pulp was, the better the effect of high gradient magnetic separation was. But considering the yield of magnetic products, the suitable velocity of pulp is 0.9 cm/s. On the basis of optimization experiment of high gradient magnetic separation, magnetic products containing Fe_2O_3 0.31 % was obtained, the removal rate of iron is 45.86 %. From the result of high gradient magnetic separation, iron removing with high gradient magnetic separator is effective.

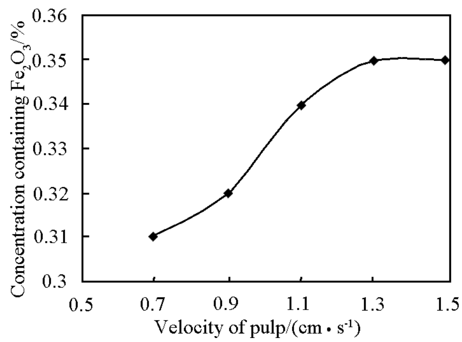


Fig. 3 The effect of high gradient magnetic separation with different velocity of pulp

4.4 Flotation

The results of flotation are given in Table 2. As seen from the Table 2, flotation can remove pyrite effectively. And suitable dosage of butyl xanthate is 200 g/t.

Table 2 The results of flotation

Dosage / ($g \cdot t^{-1}$)	Products	Yield/%	Fe_2O_3/%	Iron remove /%
Butyl xanthate 80 2# oil 60	Concentrate	94.77	0.46	—
	Tailing	5.23	1.42	14.56
	Total	100.00	0.50	—
Butyl xanthate 140 2# oil 60	Concentrate	93.15	0.42	—
	Tailing	6.85	1.73	23.24
	Total	100.00	0.51	—
Butyl xanthate 200 2# oil 60	Concentrate	92.46	0.40	—
	Tailing	7.58	1.85	27.50
	Total	100.00	0.51	—

4.5 High gradient magnetic separation of slime

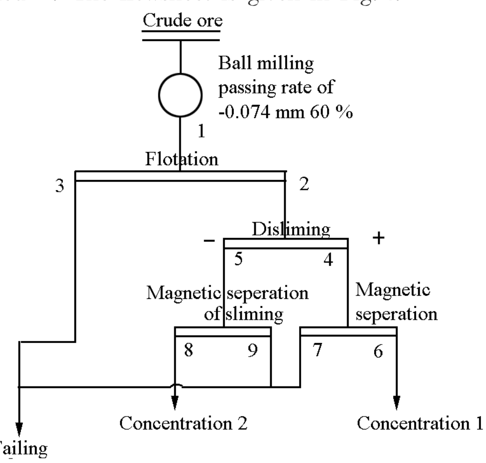
The fine iron wasn't caught by steel meshwork effectively, so the steel roll was selected for magnetic medium of high gradient magnetic separation of slime. The background magnetic intensity of high gradient magnetic separation is 1.0 T, and the results of high gradient magnetic separation are given in Table 3. As seen from the Table 3, the steel roll can catch the fine iron particle effectively, so the iron content of slime can be decreased remarkably, decreasing from slime containing Fe_2O_3 0.63 % to non-magnetic containing Fe_2O_3 0.39 %. On the basis of optimization experiment of high gradient magnetic separation, the iron content of non-magnetic can be decreased to 0.38 %, the removal rate of iron is 47.81 %. And the non-magnetic which was contained pyrite was observed with microscope. On the basis of flotation, the iron content of non-magnetic can be decreased more. So the non-magnetic of slime can be considered to reclaim.

Table 3 The results of high gradient magnetic separation

Products	Yield/%	Fe_2O_3/%	Iron remove/%
Non-magnetic	86.81	0.39	—
Magnetic	13.19	2.21	46.27
Slime	100.00	0.63	—

4.6 Recommending flowsheet

In the light of the initial trial investigations, the conclusions can be drawn: High gradient magnetic separator only removed iron that is feebleness magnetism. The pyrite that is no magnetism only used flotation to remove. And desliming was good for improving the effect of high gradient magnetic separation. On the basis of above conclusions and considering the reclaiming of slime, the flowsheet of flotation-desliming-high gradient magnetic separation was recommended[2]. The flowsheet is given in Fig. 4.



γ/%, $w(Fe_2O_3)$/%, $w(TiO_2)$/%: 1—100.00, 0.50, 0.11; 2— 92.58, 0.39, 0.11; 3—7.42, 1.87,0.12; 4—77.31, 0.35, 0.09; 5—15.27, 0.58, 0.21; 6—70.19, 0.17, 0.07; 7—7.12, 2.12, 0.29; 8—13.18, 0.32,0.17; 9—2.09, 2.22, 0.46

Fig. 4 The flowsheet of flotation-desliming-high gradient magnetic separation

From the result of mineral concentration with the flowsheet, we knew that impurities of iron and titanium could be removed effectively. Through this flowfeet, the feldspar Concentration 1 were obtained containing Fe_2O_3 0.17 % and TiO_2 0.07 % and feldspar concentration 2 were obtained containing Fe_2O_3 0.31 % and TiO_2 0.17 %, the yield of two feldspar concentrations were 70.19 % and 13.18 % respectively. And this flowsheet only throw away gangue with the yield of 16.63 %, and the removing iron and titanium of the flowsheet were 67.47 % and 35.61 % respectively. The pollution influence caused by the flowsheet was much lower.

5 Conclusions

From these investigations, the following conclusions are drawn:

1) In light of the characteristic of low quality feldspar ores, that the distribution of iron and titanium is along feldspar crystals, and the crystal of feldspar ores in the texture is large, steel ball was used as grinding medium, which can enhance the effect of grinding, and the selectivity grinding can make impurity separate from feldspar effectively.

2) Butyl xanthate can remove the pyrite contained in the feldspar ores effectively. Employing high gradient magnetic separator, the effect of removing iron was remarkable. However, employing single magnetic separation, the iron content of concentration can't meet the quality requirement of containing $Fe_2O_3 \leq 0.2$ % in the ceramic industry.

3) Through the flowsheet of flotation-desliming-high gradient magnetic separation, the feldspar Concentration 1 containing Fe_2O_3 0.17 %, TiO_2 0.07 % was obtained with the yield of 70.19 %. The feldspar Concentrate 1 can meet the quality requirement of high-grade construction ceramic. And the slime that deslimed in the flowsheet is also separated, the feldspar Concentration 2 containing Fe_2O_3 0.31 %, TiO_2 0.17 % was obtained, with the yield of 13.18 %. The feldspar Concentrate 2 can be used for raw material of low-end glass. And this flowsheet only throwaway gangue with the yield of 16.63 %, the efficiency of separate is high. Employing this flowsheet can also bring high economy benefit and low influence on pollution of the environment.

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